Climate Variability and California Low-Level Inversions

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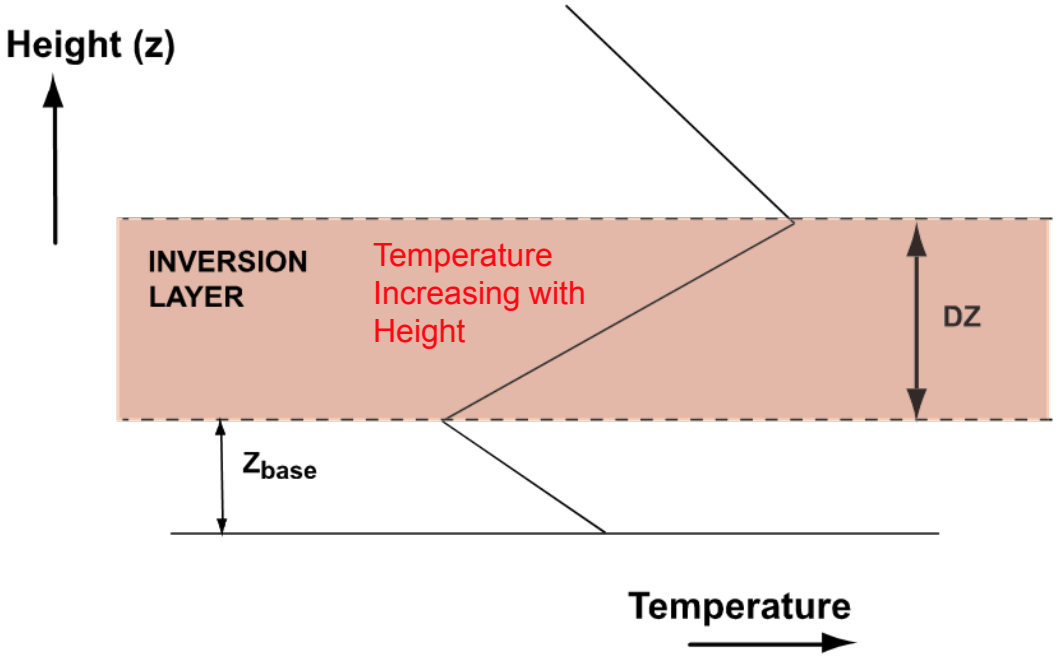
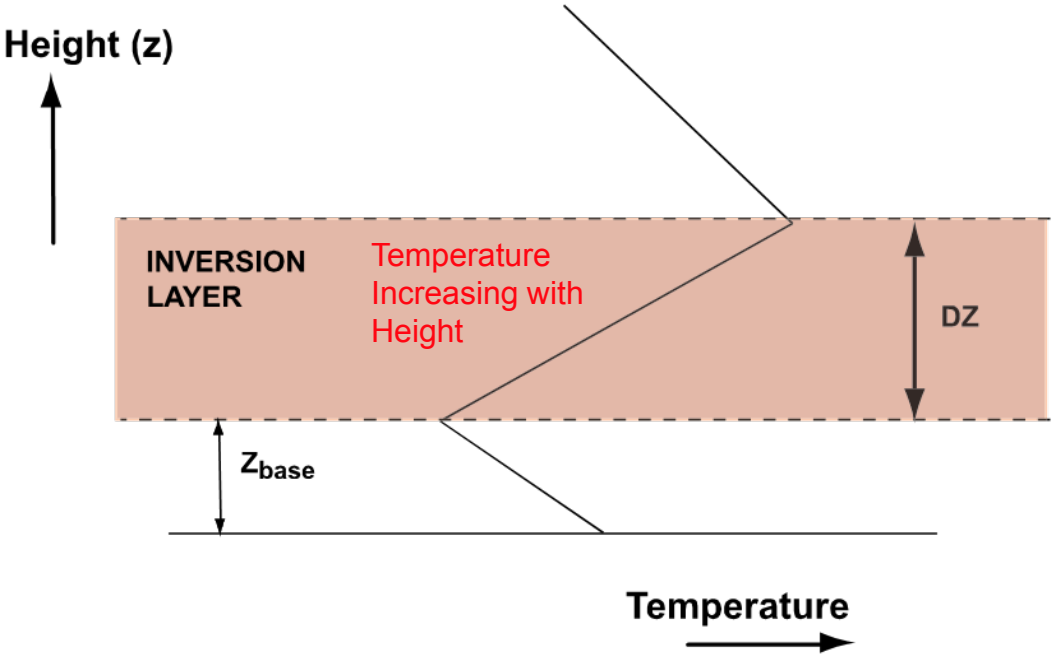
Outline:

- Background
- Inversion Measures
- Relationship of Inversions to Large-scale Circulation
- Trends in Inversion Characteristics

Inversion Layer Schematic

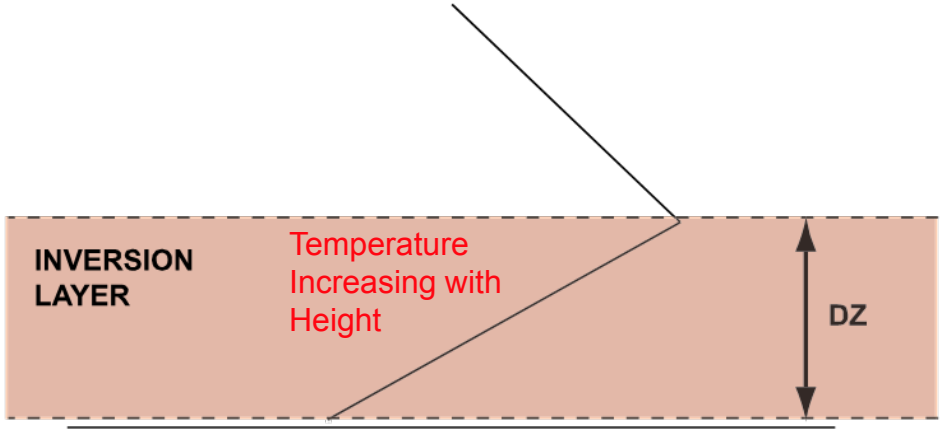


Inversion Layer Schematic



Subsidence Inversion

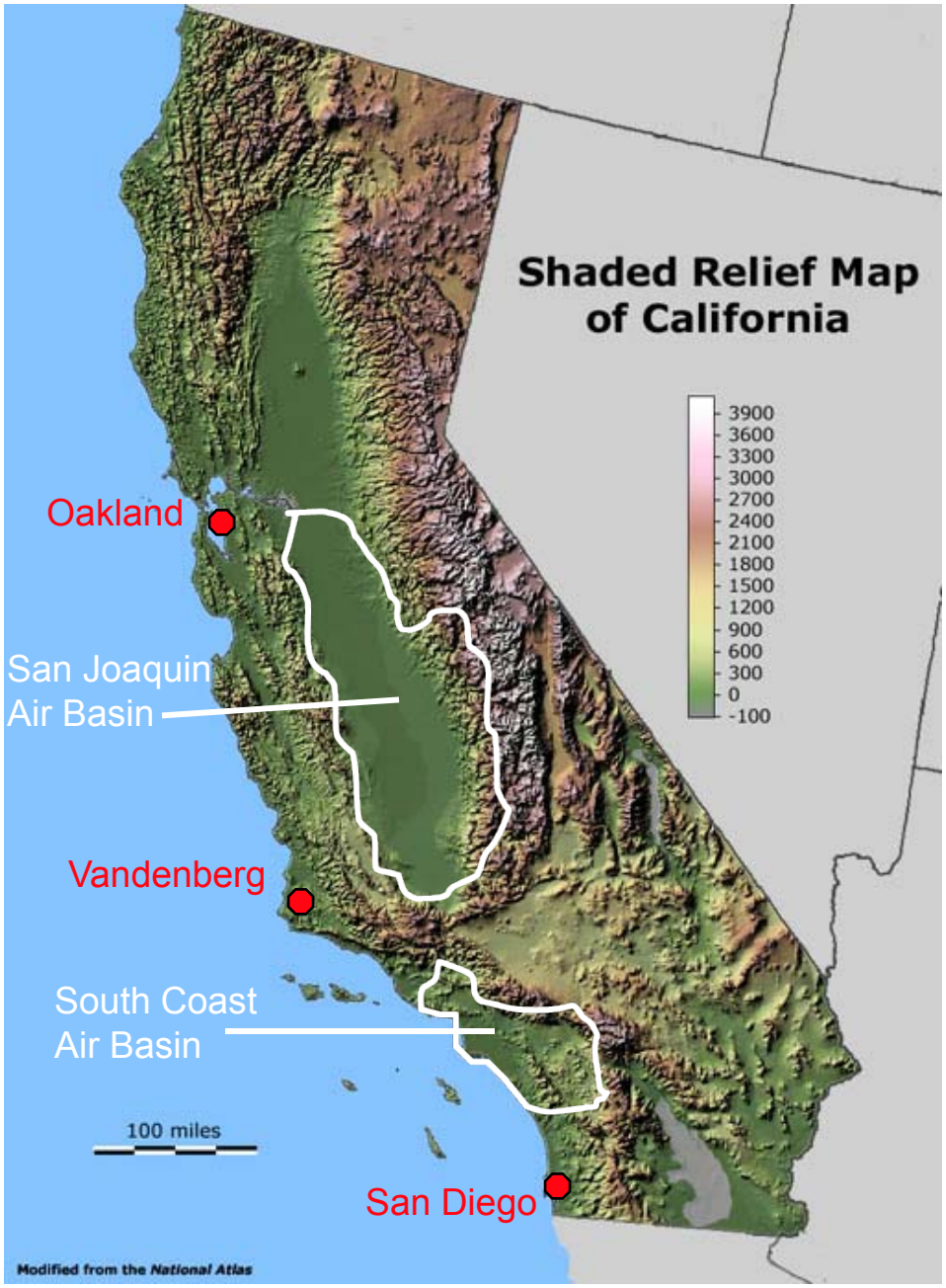
Surface-Based (Radiation) Inversion (Z_{base} = 0)



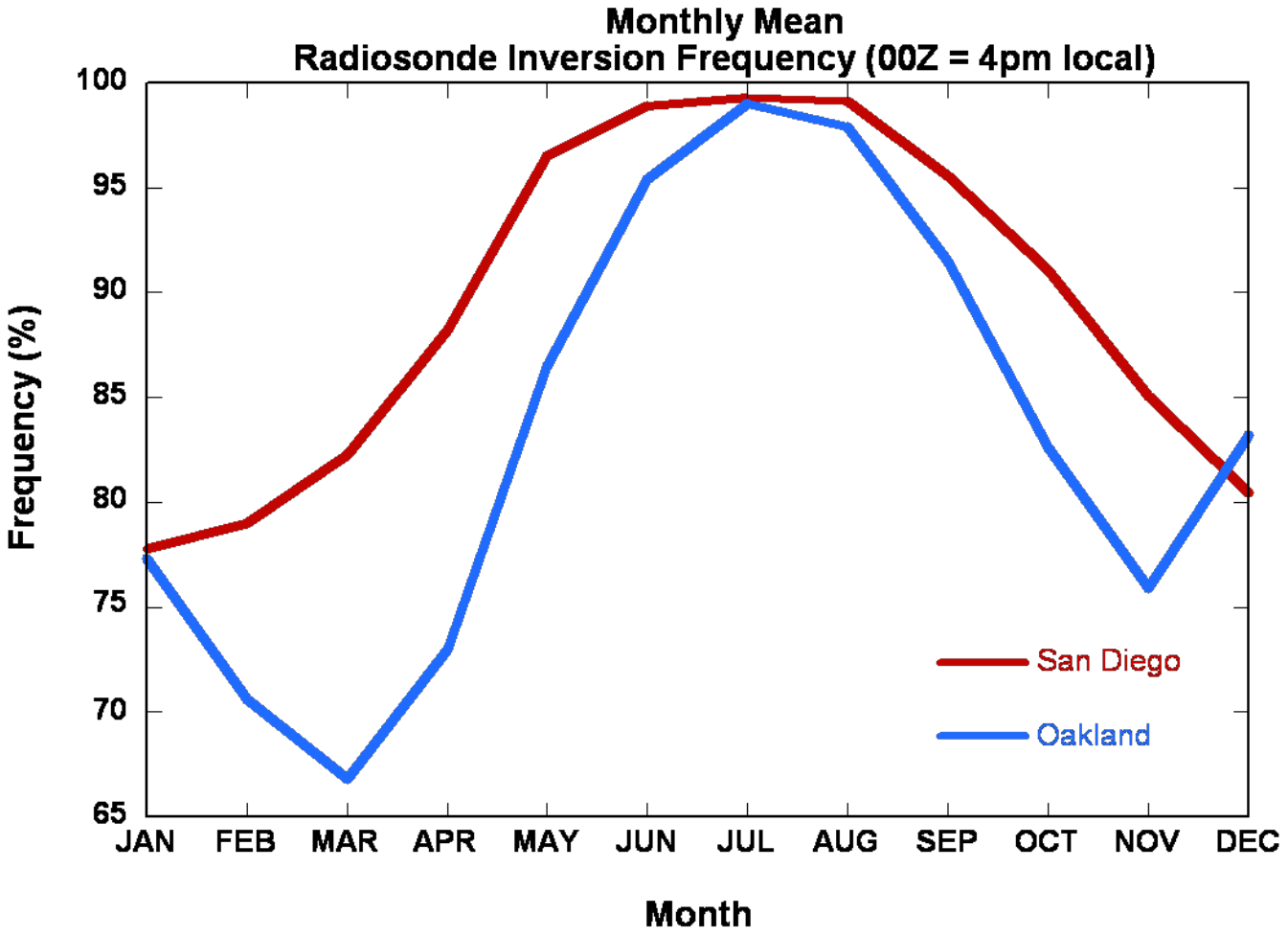
Weather Balloons (Radiosondes)

- Obtain vertical profile of temperature, humidity, wind, and pressure

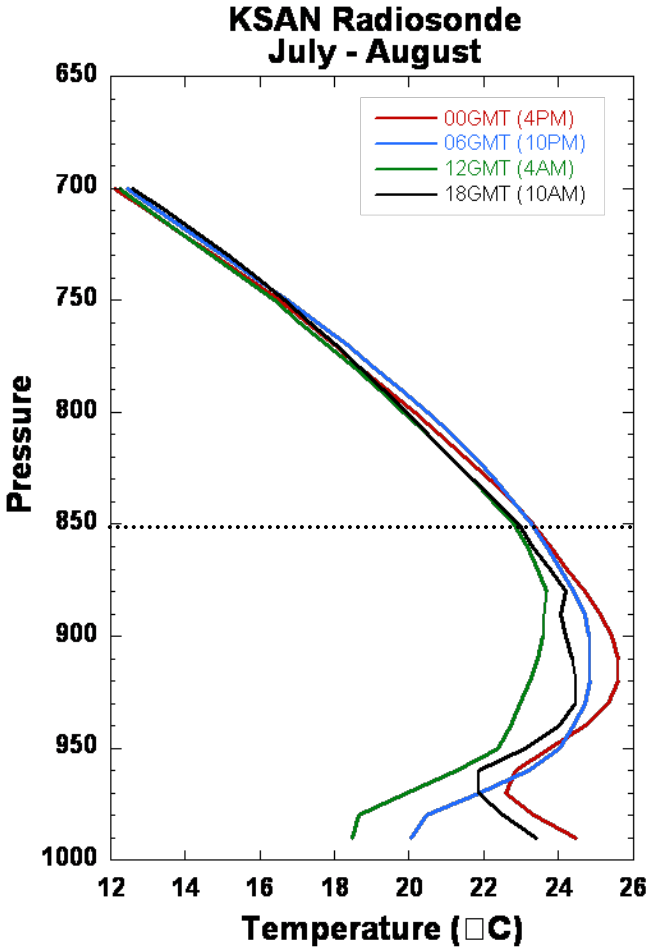
- Routinely launched in California at **Oakland**, **Vandenberg** and **San Diego** 12Z (4am local) and 00Z (4pm local)


Shaded Relief Map
of California
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
-100
Oakland
San Joaquin
Air Basin
Vandenberg
South Coast
Air Basin
100 miles
San Diego
Modified from the National Atlas

Inversions vary seasonally, but are a dominant feature in California air basins



Temperature Inversion Measures



Mean temperature profile at San Diego as a function of time of day.

Temperature Inversion Measures

Possible Measures:

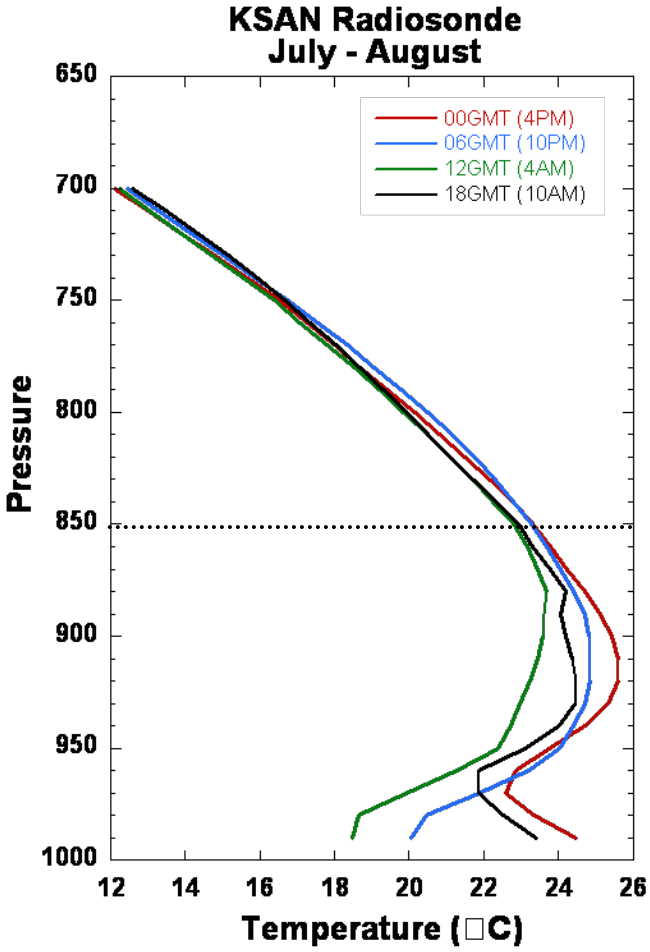
$DTINV = T_{TOP} - T_{BASE}$

$DT850 = T850 - T_{2M}$

T850 = Temperature at 850 mb

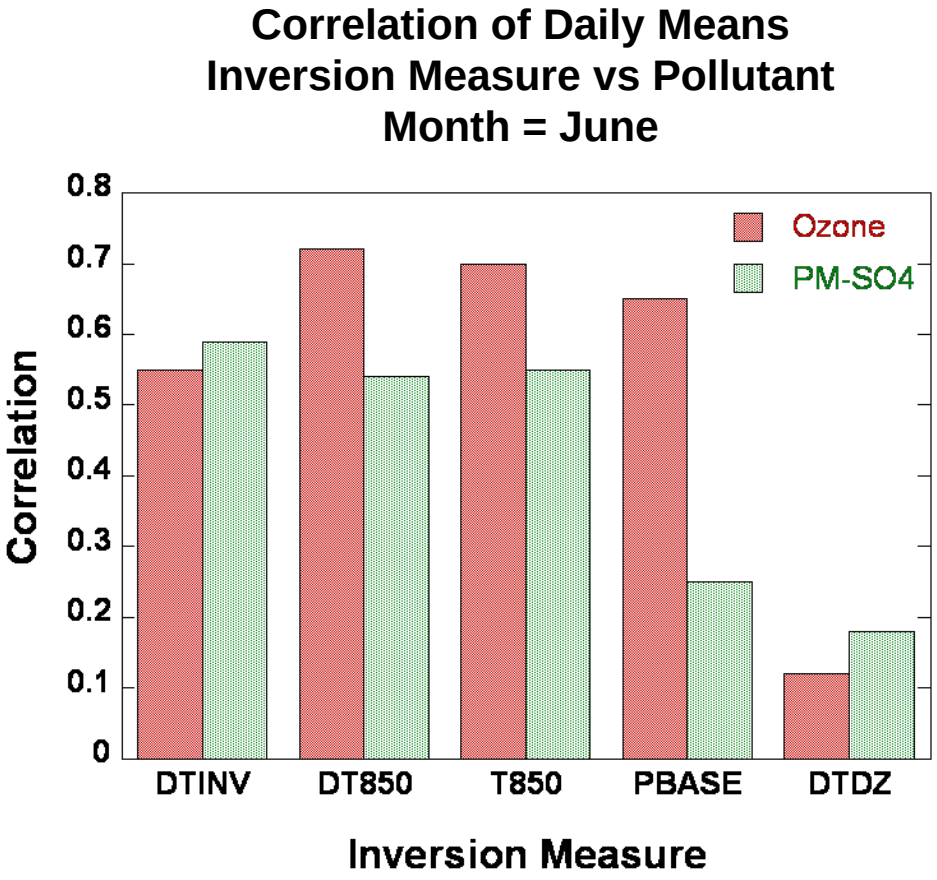
DTDZ = lapse rate within inversion

PBASE = Inversion base pressure



Mean temperature profile at San Diego as a function of time of day.

Temperature Inversions and Pollution



Relationship of inversion strength to large-scale circulation

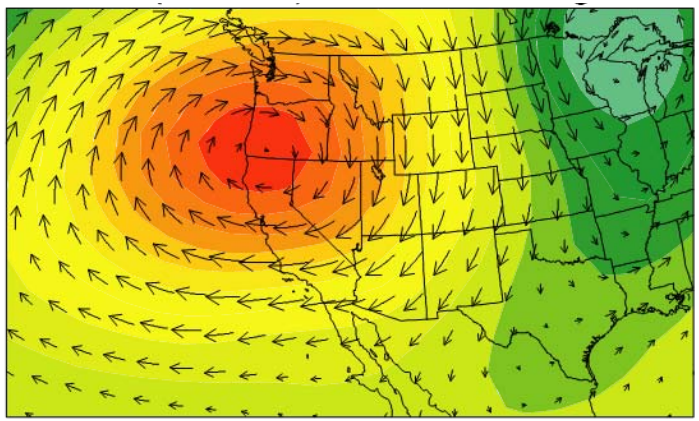
Model data from:

- NCEP Reanalysis 2 (2.5° x 2.5°)
  - similar resolution to most climate models
  - hindcast
  - incorporates available observations
  - represents best estimate of atmospheric state 1979-present

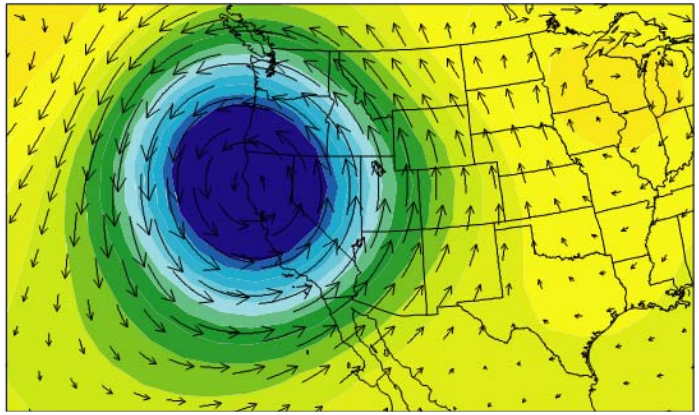
Composite Daily Atmospheric Patterns During Strong/Weak Inversion Events

- examine weather balloon data at Oakland (Jun-Aug 1979-2001)
- find the 30 events with largest/smallest inversion magnitudes
- examine mean large-scale circulation for these 30 events
- consider anomalies (departure from long-term average)

500mb Height and Wind Anomalies



Strong Inversions
at Oakland



Weak Inversions
at Oakland

- Strong inversions associated with above normal 500mb heights (large-scale high pressure systems)

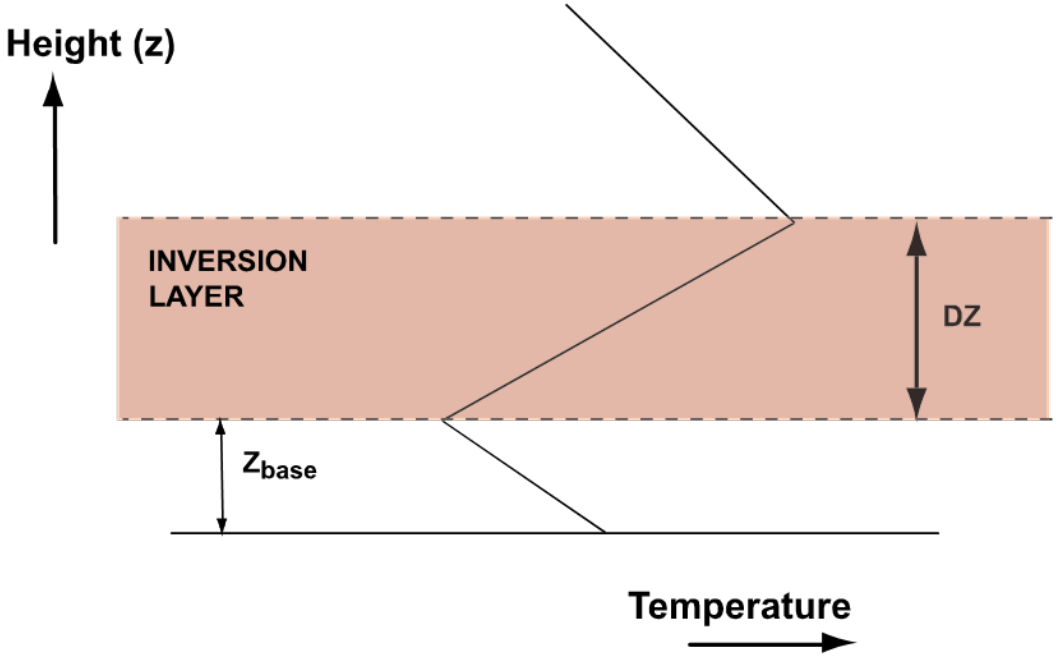
- Weak inversions associated with below normal 500mb heights (large-scale low pressure systems)

===> Inversions in California associated with large-scale circulation

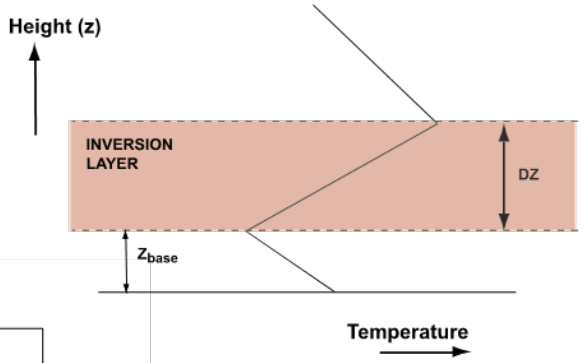
Temperature Inversion Trends:

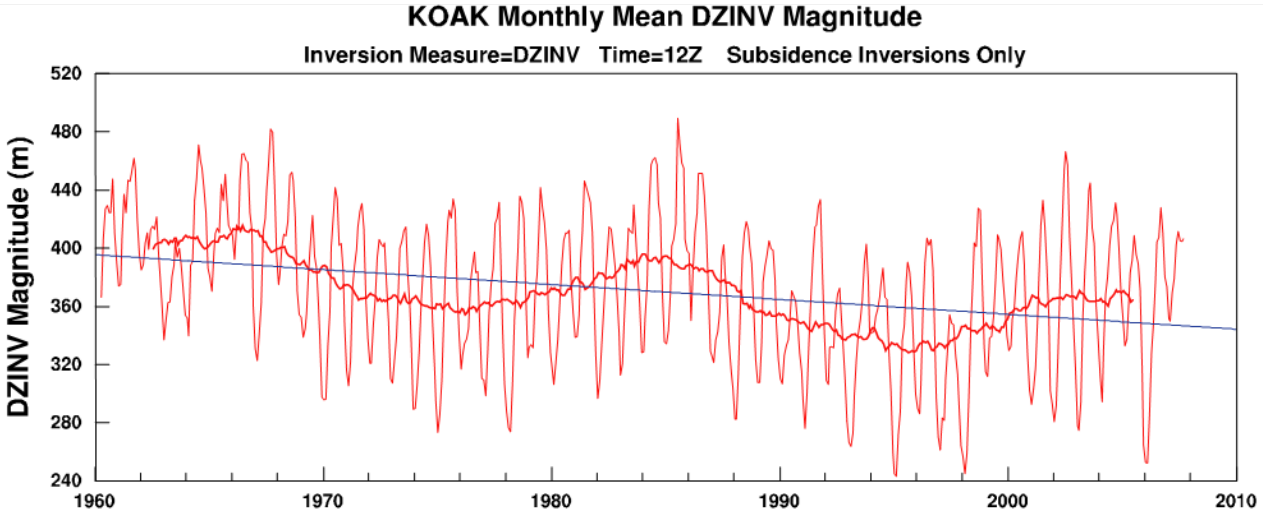
Radiosonde Data Set 1960 - 2007 (48 years)

Temperature Inversion Trends:
DZINV (Inversion Thickness)

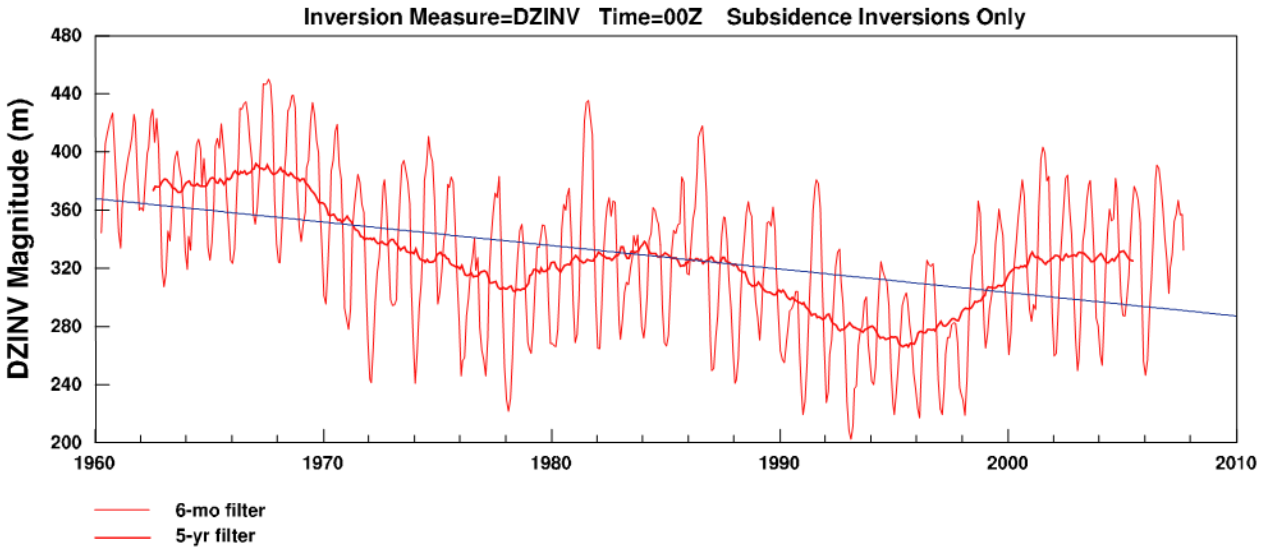


Temperature Inversion Trends: DZINV (Inversion Thickness)



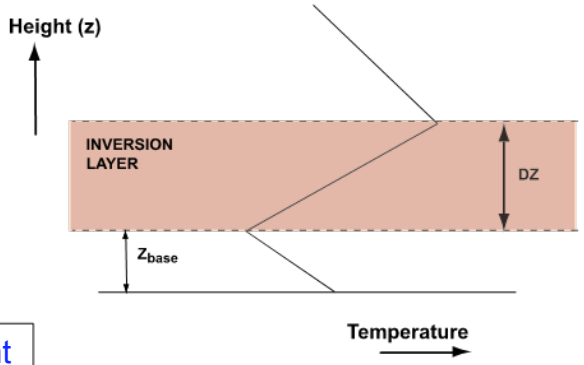


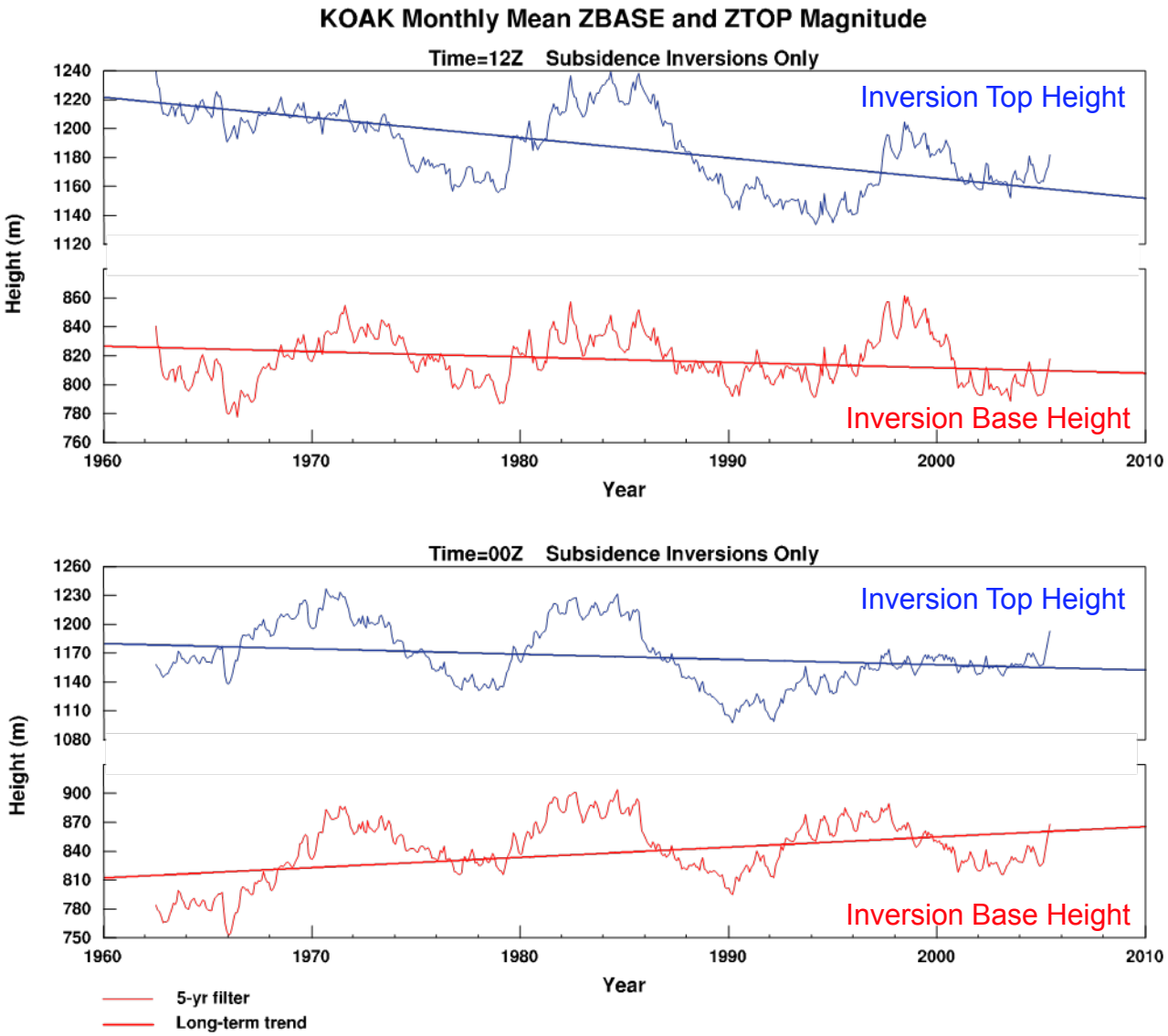
ΔDZINV=49m (12%)



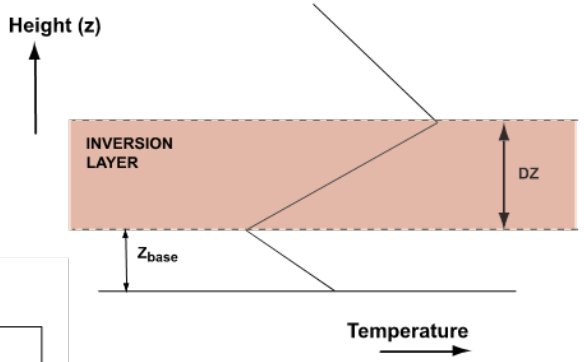
ΔDZINV=77m (21%)

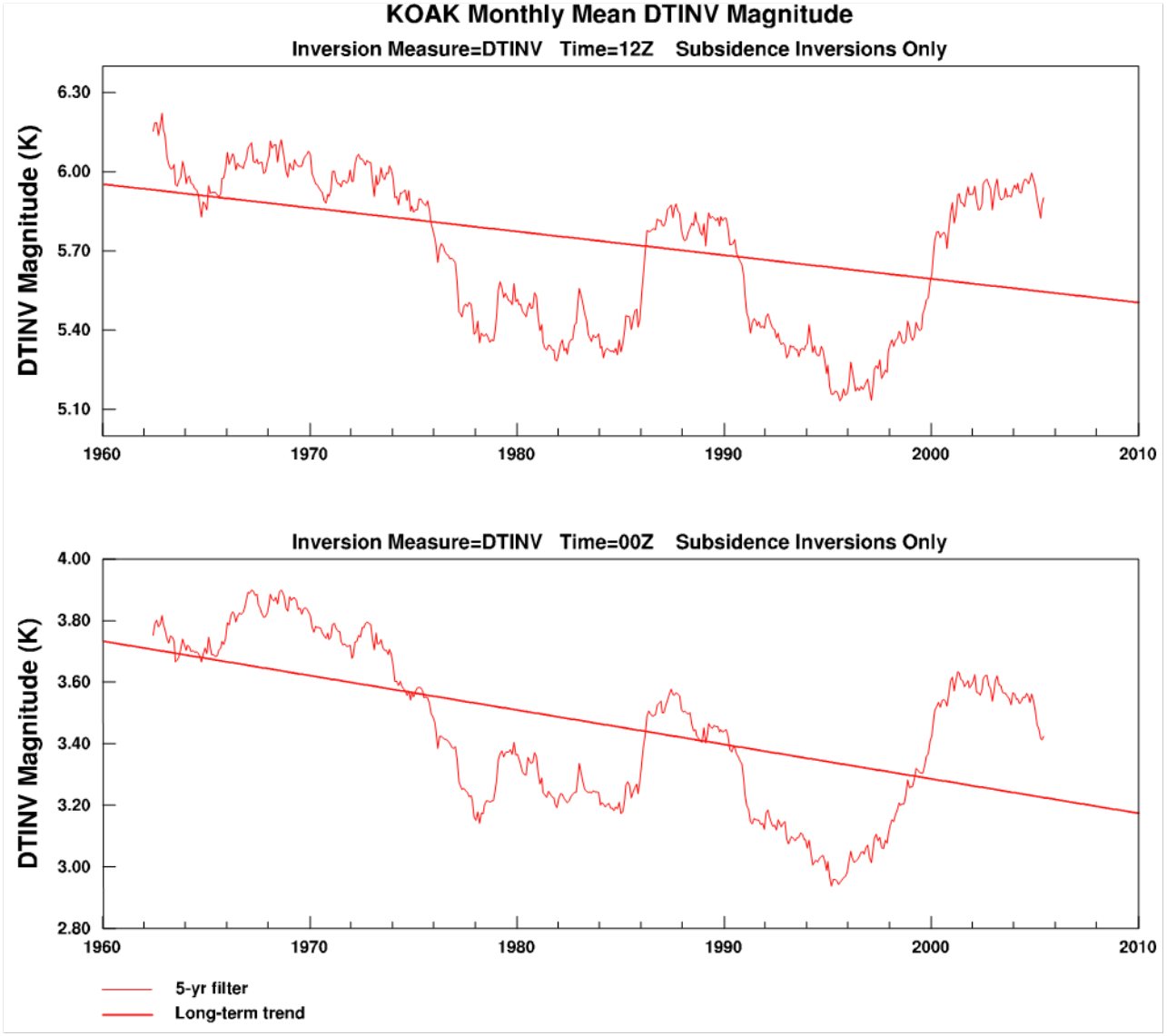
Temperature Inversion Trends: Z_{BASE} & Z_{TOP} (Inversion Top and Bottom)





Temperature Inversion Trends: DTINV (ΔTemp across Inversion)





ΔDTINV=0.43°K (7%)

ΔDTINV=0.53°K (14%)

Trends in the Frequency of Strong Inversions: DTINV (ΔTemp across Inversions)

Appears that DTINV on average is decreasing

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Is the frequency distribution also changing?

- more moderate inversions and less weak/strong inversions?
- or visa-versa?

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To examine frequency distribution need to detrend DTINV time series

- removes long-term trend in the mean
- preserves shape of the frequency distribution

Trends in the Frequency of Strong Inversions: What is a Strong Inversion?

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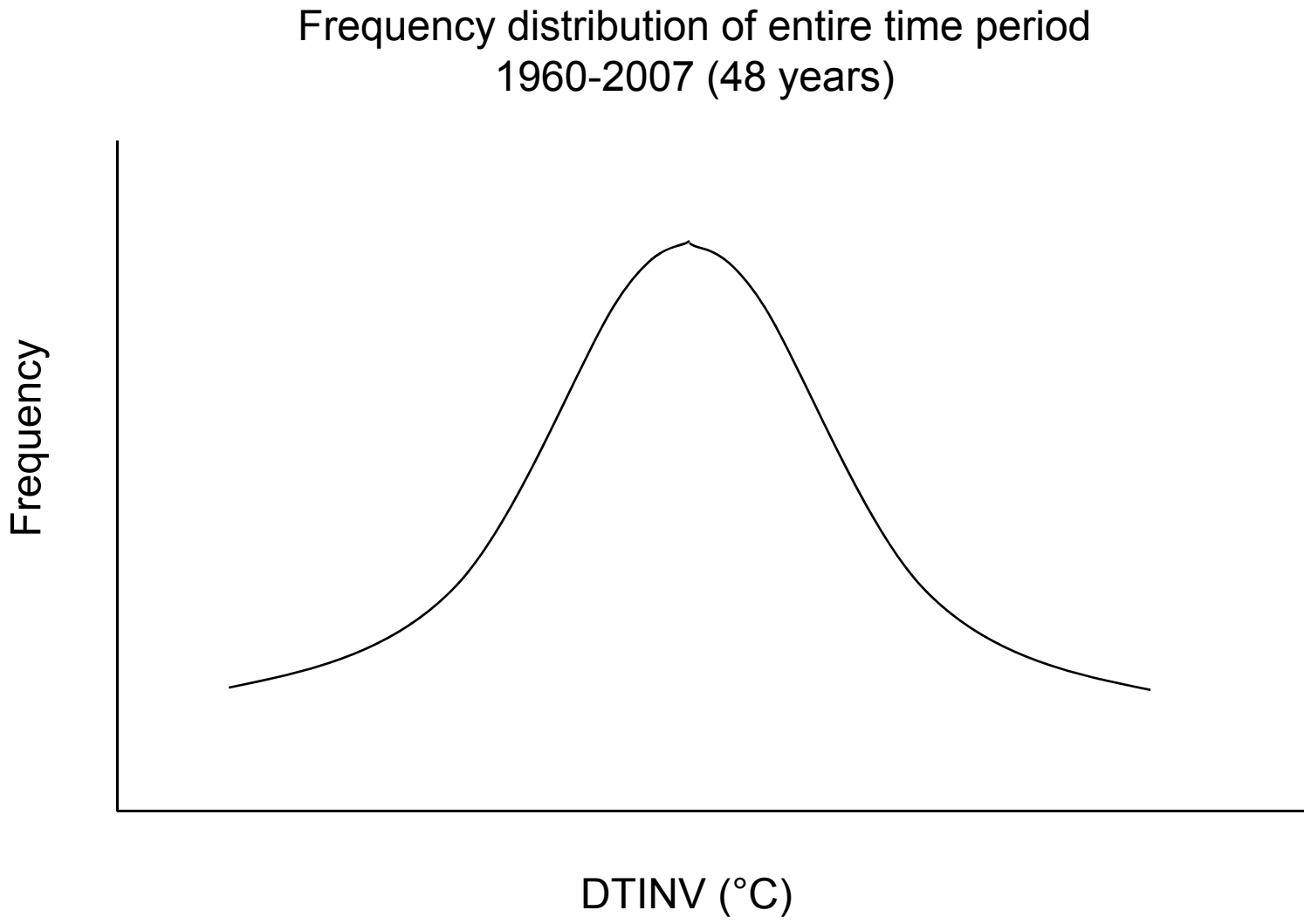

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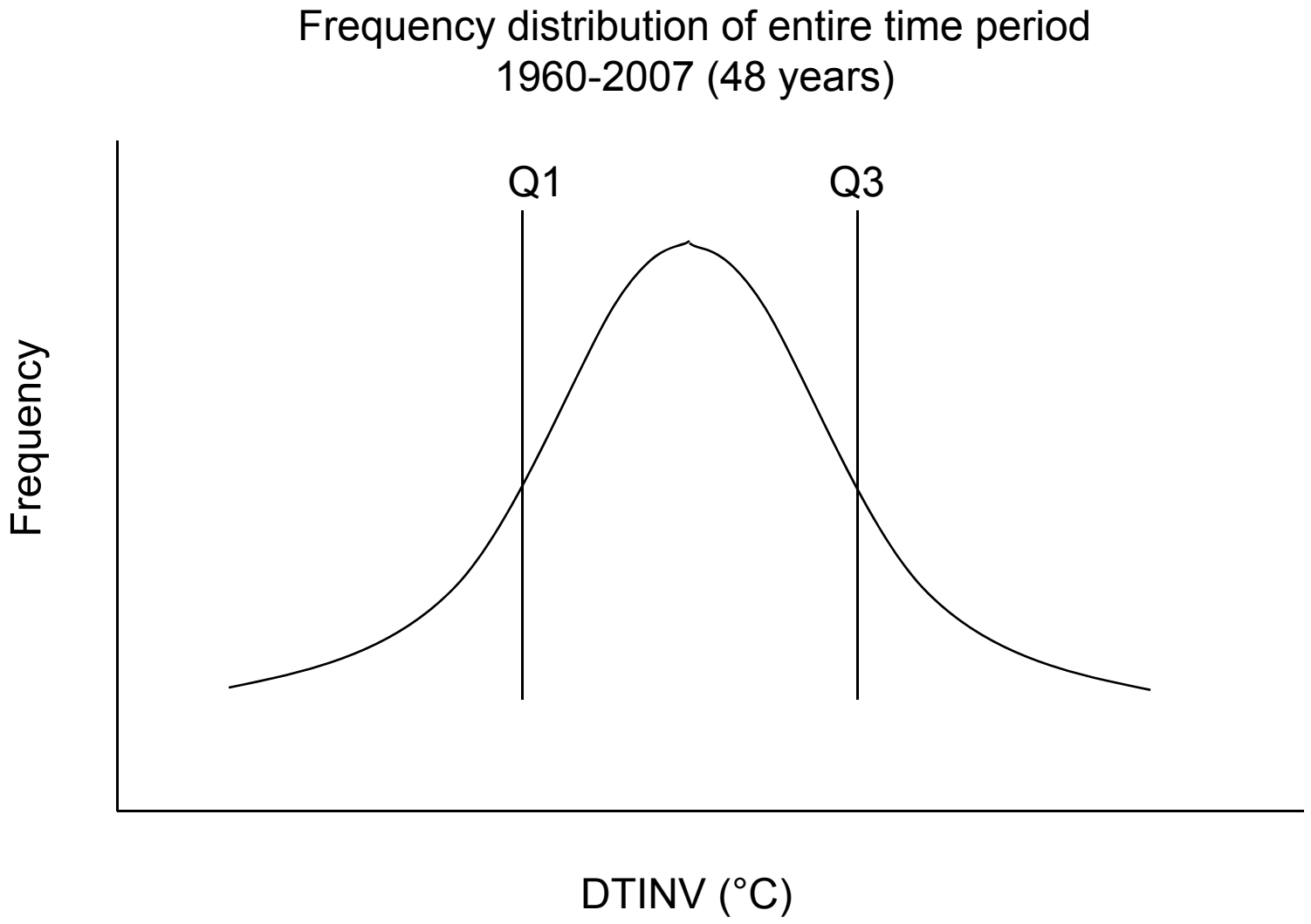

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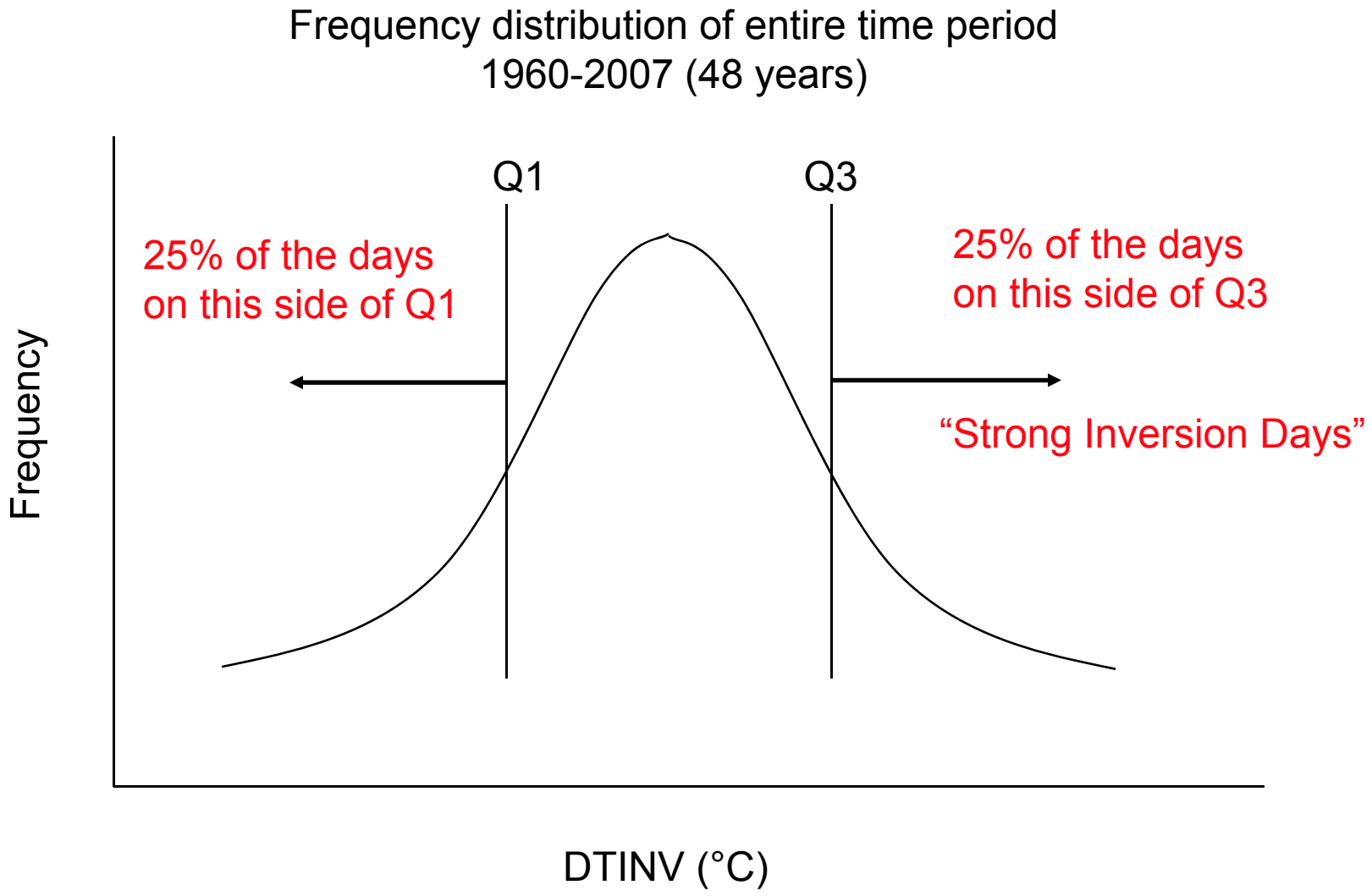

Trends in the Frequency of Strong Inversions:

Days per year DTINV above Q3 value

	1960-1983	1984-2007
KSAN 12Z	90	84
KOAK 12Z	81	81

Trends in Persistence of Strong Inversions

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Define a Persistent Episode as:

3 or more continuous days with strong inversion

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(using DTINV as inversion measure)

	1960-1983	1984-2007
KSAN 12Z	59 Days	53 Days
KSAN 00Z	50 Days	42 Days
KOAK 12Z	57 Days	57 Days
KOAK 00Z	45 Days	42 Days

Summary

- Low-level temperature inversions are a consistent feature in California air basins as evidenced at San Diego and Oakland (additional soundings at inland sites currently being examined).

- Inversion measures using temperature at top or across inversion show higher correlation to pollution.

- Inversion intensity is strongly linked to large-scale circulation features (e.g., CA Central Valley during Spring).
  - climate change simulations provide large-scale structure
  - may allow us to project trends of inversion magnitudes and frequencies.

- Over last 48 years:
  - Decreasing inversion thickness and ΔT across inversion
  - Reduction (slight) in “strong inversions”
  - Less persistent episodes of strong inversions
  - Based on radiosonde measurements at Oakland and San Diego

Ongoing and Future Work

- Examine historical trends at additional locations (e.g., inland)
- Produce more quantitative products relating large-scale circulation to inversion characteristics for California air basins
- Examine how inversion frequency/magnitude related to warm/cold periods in historical record
- Investigate role of decadal climate modes and ENSO on circulation patterns and inversion characteristics
- Use GCM climate simulations and downscaling to examine potential future changes in low-level inversions.